EXPERIMENTS ON THE SENSE-ORGANS OF INSECTS.

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THE interesting experiments of Mr. Trouvelot, described in the April NATURALIST, which it should here be explained were in my hands eight years before their final publication, the MS. having been overlooked, led me to make similar experiments, which are offered here with the hope of stimulating some more competent observer to work up the subject in a more complete and scientific way.

From a worker honey bee (*Apis mellifica*) I removed one antenna. It flew with difficulty and acted as if much hurt. On removing the other, except the first and second joints of both antennæ, it appeared to be semi-paralyzed, and on being tossed up in the air fell helpless to the floor, and did not at first walk about much, but in two or three minutes recovered sufficiently from the shock of the amputation to walk, though it had apparently lost the power of coördination and also the power of stinging; but it soon recovered its strength enough to fly a little, and began to dart out its sting, but most of the time it buzzed about on the table on its back. After four or five minutes it came to, and flew with a comparatively steady flight to the window on being thrown up in the air. It then walked up the window-pane.

On removing the stumps of both antennæ it was partially paralyzed, and dropped repeatedly on the floor upon being thrown up in the air. It did not regain its wits as soon as before, but remained on the window-sill walking about, not climbing up the pane. It, however, had the power of partially coördinating its steps, and would now and then clean its feelers (palpi) by drawing them through its jaws. It would not sting me even on pressure with the finger. Fifteen minutes afterwards it had not recovered the power of flying, and in essaying flight would fall on its side, buzz about on its back, and then walk staggering along. The movements of the mouth-parts were not affected. One hour after deantennization it would remain motionless, and on violently tapping the window-sill on which it rested it would not stir, but on touching it slightly it moved a little, and soon became motionless; after this a still heavier tap would slightly startle it. Upon depositing a drop of dissolved sugar within a line of its head it did not notice it; on daubing it over the end of the

stump of the antennæ no movement was made by the bee, but as soon as the fluid had spread and moistened the mouth-parts it unbent its maxillæ and vigorously lapped it up, the tongue (lingua) playing back and forth between the maxillæ as the latter spread open a little. During this operation I held the bee between my fingers; it did not sting me, but soon thrust the sting partly into the skin of my finger, showing that the power of stinging had partially returned.

This experiment seems to show that the sense of hearing may reside in the antennæ of the honey bee, while that of smell has its seat in the palpi (and perhaps the tongue) alone. It would also seem as if the antennal nerves were so continuous with the supraœsophageal ganglia that they are as it were part of the brain, their removal at a little distance from their origin producing such a shock to the ganglionic nervous system that the insect acts somewhat like a bird on being deprived of the cerebral hemispheres, while the special senses in the organs left untouched are not affected. The bee was more profoundly impressed by the mutilation than other insects, as will be seen by the following experiments, and this is evidence in favor of the view that the Hymenoptera and the honey bees especially, stand at the head of the insect creation.

On removing the antennæ from a species of *Andrena*, a common wild bee, it immediately fell on its back as if stunned, and lay on its side curled up as though hurt, and on letting it fall would drop down and lie still on the table, not trying to use its wings. It laid several hours on its back and then died. On the other hand a smaller species, about half the size of the other, on being treated in the same manner did not seem to be much affected, as it walked about in its usual lively fashion on the table and finally flew out of doors. A small *Halictus* and *Augochlora* bee, after the loss of their antennæ, flew with a little less directness and freedom, but showed no signs of being hurt. A humble bee (*Bombus Virginica*) and wasp (*Vespa maculata*) on being deantennized acted in much the same manner; on being thrown up in the air they would repeatedly fly to the window, not being stunned as in the honey bee, though they were somewhat affected, occasionally falling over on to their backs and remaining there several minutes. A second wasp of the same species acted in the same manner after the same style of treatment. On placing dissolved sugar on the stumps of both antennæ, no impression was made upon it, though when put to its

mouth it eagerly lapped the sweet. Finally the wasp flew out of the window.

I removed the palpi or feelers from a female *Polistes* wasp, leaving the stumps of the maxillary palpi. It did not eat the sugar with its usual heartiness, but still extended its tongue slightly. One experiment like this proves nothing, but suggests that the sense of smell or taste probably resides in the tongue and base of the maxillæ of these insects as well as in the palpi.

A female blue mud dauber (*Pelopœus cœruleus*) on removal of the antennæ showed no less activity than before and flew and ran about in its ordinary manner.

A large blue-black ichneumon-fly on removal of the antennæ was not affected much. On placing a lump of sugar at its mouth it eagerly lapped it, but on removing both pairs of palpi, leaving short stumps, it did not lap the sugar, though I repeatedly put it close to its tongue and actually plastered the solution on the tongue. I also put the insect into a cup with a solid mass of sugar at the bottom, but it did not eat it, having apparently entirely lost the sense of taste. In this insect it would seem as if the sense of taste resided in the ends of the palpi. Previous to their excision they moved very briskly while the ichneumon was lapping the sugar with its tongue.

In walking up the side of the glass as well as on the table it felt its way in a peculiar tentative manner with its left fore leg, the short stumps of its antennæ all the while moving, showing that the antennæ rather than the eyes are used in walking, and that when deprived of its antennæ and eyes it uses one leg like a blind man his stick to feel its way.

An ichneumon of another species on removal of its antennæ and of the labial and the terminal half of the maxillary palpi, lapped sweetened water.

A small *Microgaster*, on partial removal of the palpi, leaving only the stumps, acted like the larger ichneumons.

A small brown ant on losing its antennæ was at first evidently much shocked, turning round and round in a confused manner, but in a minute or two it walked off nearly as well as ever. It found its way to the rim of a goblet and lapped the sugar solution with its tongue, the maxillary palpi being extended straight backwards. It cleaned its fore legs, drawing them through the maxillæ.

A number of butterflies and moths were experimented upon. On removal of its antennæ a *Papilio Asterias* flew irregularly to

the floor, remaining there; on opening the window it flew out heavily, having evidently lost some of its powers of flight and of directing the movements of its wings. It remained just where it had settled in the path from four P. M. until after nine o'clock the next morning. Then on putting it in a sunny place it disappeared five minutes after, and must have become warmed and flown away.

A *Colias Philodice* on removal of its antennæ did not fly quite so readily as one in the same room unmutilated, but the difference was not marked; two deantennized *Pieris rapæ* behaved in the same manner as the *Colias*.

An *Argynnis Idalia* in losing its antennæ seemed but slightly affected, but showed more of a tendency to drop to the floor than if in a natural condition. On putting sweetened water on the ends of the stumps of the antennæ, in a minute it partly but not wholly unrolled its maxillæ. On moistening the ends of the labial palpi no effect was produced; on moistening the base and ends of the maxillæ they at once unrolled and felt about for the sweet object with their tips, and on putting a drop of sweetened water on the window frame in front of it, it eagerly lapped it with the maxillæ, and on losing the place of the drop it felt around until it found it and then again lapped it. This experiment tends to show that both the sense of taste and touch must reside in the maxillæ of the Lepidoptera, and not in the palpi.

On removing the antennæ of a *Deilephila lineata* which had just come from the chrysalis, it seemed to fly more vigorously than before, and to be rendered more restless in its motions. On snipping off the antennæ of an *Agrotis subgothica* which came in at a lighted window, it tumbled about headlong at times, being evidently top-heavy and confused. Another owlet moth, *Drasteria erechtea*, on losing its antennæ did not seem to suffer, and soon recovered sufficiently to fly out of the window upon the grass and to start up in its usual manner and fly off at my approach. A *Crambus* similarly treated acted in a similar manner.

The sense of touch in the Lepidoptera does not evidently reside in the antennæ alone, and all the experiments show that after the loss of the antennæ if disturbed, jarred, or touched, they are still sensitive and fly off.

A few flies were experimented upon, the antennæ being snipped off. A *Chironomus* was much affected; it flew about wildly bouncing on its head, and did not fly up the window-pane upon partial recovery. On the other hand no effect was pro-

duced on a *Tipula* or daddy-long-legs. A large blue-bottle fly (*Musca Cæsar*) seemed to suffer no ill effects, and it was found flying on the window the next day, lively and apparently unconscious of its loss.

Three *Stomoxys calcitrans* on losing their antennæ seemed not at all affected, being as lively as ever, wiping their feet and running and flying up the window, with motions identical with others of their species on the same window.

On removing the antennæ from a beetle (*Harpalus caliginosus*) no difference in its motions was observed; a *Clytus robiniæ* seemed, however, slightly discommoded, while an *Ellychnia corusca*, when mutilated, walked slowly and with difficulty, where before it walked with moderate rapidity touching the ground incessantly with its antennæ; it did not move in a direct line, but hesitatingly, and sometimes tumbling over on one side. It was evidently gravely affected, and finally remained quiet for several hours; a potato beetle (*Leptinotarsa decem-lineata*) acted in the same manner. On the other hand a weevil, *Hylobius pales*, on losing its antennæ, exhibited no signs of discomfort; it did not feign death at first, nor did it walk over the table with a less well directed gait than before.

A few Hemiptera, which, it should be observed, have no palpi, suffered the loss of their antennæ. *Cicada canicularis* flew about more lively than before it was operated upon. In *Coreus tristis* no effect was produced, while a large *Arma*-like bug was made more sluggish.

The red-legged grasshopper (*Caloptenus femur-rubrum*) was not affected, nor was *Orchelimum agile*, while a cricket (*Nemobius vittatus*) on losing its antennæ, at once stopped, not leaping more than two inches, and walked slowly, but used its palpi in walking, cleaning its legs with them. On removing the labial palpi its movements were not different, though, if anything, livelier. On removing the maxillary palpi, no difference in its actions was produced. A common *Gryllus*, in losing its antennæ, was but slightly affected.

A large dragon-fly, *Æschna heros*, on the loss of its antennæ, seemed to fly freely about the room, but would butt against the wall, and on being taken out of doors, flew to the ground, where it usually flies rapidly off in the air.

Spiders seemed to be affected by the loss of their maxillary palpi much as insects by the loss of their antennæ. A female *Lycosa*-like spider, after the removal of its palpi, for four or five

minutes moved slowly, but with a direct, well coördinated gait, then it partly recovered, and moved more briskly. Another smaller *Epeira*-like spider did not seem to suffer, except that its motions were slower, and on being touched, it would gather up its legs and feign death.

A species of *Julus* and of *Polydesmus*, on amputation of their antennæ, rather long stumps remaining, were at first somewhat discommoded and then seemed to walk well, but less rapidly than before.

It would be premature to draw any inferences from these experiments, but the impression is left on the mind that in removing the antennæ in some cases, it seemed as if something more was effected than making the insect deaf or depriving it of the sense of taste or smell, and it seemed as if the ganglionic centres were affected, particularly the supra-œsophageal pair, the insect being at first more or less stunned or confused, and then, in many cases, acting as if the nervous centres were permanently affected; not so much as if one of its senses, but all or nearly all, were more or less affected. In fact, the movements somewhat resembled those of a dove from which the cerebral hemispheres had been removed, as in the case described in Dalton's Physiology, and the fact that the insects can distinguish light from darkness, perhaps the main function of the eyes, and taste their appropriate food, does not militate against the idea that the nervous centres are seriously affected. On the other hand, no such effects are produced when the leg, or even, in some cases, the abdomen, is removed. I do not see that my experiments enable us to prove anything as to the nature of the function of the antennæ, except to indicate that the insect's brain is as it were projected into them, and that their nerves probably possess nucleated cells, homologous with those of the ganglia from which the sense-nerves originate.

RECENT LITERATURE.

Ganin's Metamorphoses of Insects.[1] — The author begins with a rapid survey of previous investigations by Weismann, Uljanin, Chun, Paul Mayer, Auerbach, and shows the unsatisfactory condition of our knowledge and the necessity of a verification of the statements of those

[1] *Materials for a Knowledge of the Post-Embryonal Development of Insects.* By Professor M. Ganin. Warsaw. 1876. 4to, 76 pages and 4 plates. (Extracted from the Transactions of the Fifth Meeting of Russian Naturalists in Warsaw; Section of Zoölogy and Comparative Anatomy.)